# Chapter 10

# Underdetermination, Induction, Falsifiability

## 10.1 Homework

**Readings** – DW 5-7 + Duhem, Russel and Popper

**Study Questions** – Give a short answer to the following questions:

1. What are the three main claims constituting the Duhem-Quine thesis? Explain how these claims can be interpreted either in a rather weak and uncontroversial way, or in a stronger and more controversial way.
2. What is the axiomatic method? Explain why it is hard to see such a method work in natural sciences. Is there another domain in which it works well?
3. What is the hypothetico-deductive model? How does it fit your views on science?
4. Explain what the problem of induction is (as formulated by Hume). Explain why appealing to the fact that induction has always worked in the past is a circular argument.
5. Explain Hempel's raven paradox. What is the proper conclusion that we should take from it.
6. Explain Goodman's new riddle of induction.
7. Explain what it is to treat a scientific theory as unfalsifiable. Explain why falsifiability is better understood as an attitude than as a property of a theory.
8. Dewitt states p. 64: "[...] the issues discussed above are clearly philosophical issues, rather than issues that affect working scientists". Do you agree? Why? Why not?

## 10.2 A rough history of philosophy of science up to early 20th century

**Aristotle and the Axiomatic approach** –

**Deductive reasoning** for "certain" knowledge

Agree on the most general principles and definitions: axioms

Once we have agreed on the principles (the axioms), everything should logically deduced, such that the conclusions, if the principles are true, are necessarily true.

**Use of deductive logic** – syllogisms

Proper scientific knowledge is demonstrative – by a chain of syllogism

**Model** – Euclidian geometry

Axioms of Euclidian geometry:

1. Any two points can be joined by a straight line.
2. Any straight line segment can be extended indefinitely in a straight line.
3. Given any straight line segment, a circle can be drawn having the segment as radius and one endpoint as center.
4. All right angles are congruent.
5. Parallel postulate. If two lines intersect a third in such a way that the sum of the inner angles on one side is less than two right angles, then the two lines inevitably must intersect each other on that side if extended far enough.

Everything else is deduced from these axioms.

**The problem of the first principles** – regressio ad infinitum? How to start the chain of deductions? We cannot prove the principles by deduction!

Dewitt says : necessarily true = certain knowledge. There is a subtlety here: I would say that the scientific statements have to be, for Aristotle, necessarily true *if the general principles are true*.

These general principles are either induced from experience, or taken from common sense / intuition, or obtained as the outcome of a rational dialogue among experts in the domain. *Aristotle's method has a pragmatic basis.*

On the first principles, Dewitt says: intelligent people will see the first principles as necessary truth about the world. Takes the fifth postulate as an example – rather unfair it seems to me, because it is precisely the least "intuitive" of the five axioms of Euclidian geometry. Other principles are more clearly intuitive:

- Other axioms of Euclidian geometry
- Principle of contradiction, for which Aristotle provides an interesting argument if not a proof

That said, his point is to say that it is possible to make mistakes in following Aristotle's method. We should not conclude that mistake is necessary, but he makes a good point saying that the method is not reliable. We can grant the point that science cannot work that way

**Descartes** - Hyperbolic doubt

- One single certain truth: "I am, I exist"

- That said, just as in the case of Aristotle and the principle of contradiction, Descartes' cogito is not enough of a foundation for making claims about the world

**Philosophy of Science early 20th century** :

**As a result of** :

1. Classical theory's success
2. Marx, Freud, and other "pseudo-sciences"
3. QM and Relativity

$\longrightarrow$ *Logical Positivism: Attempt to give a definition of the scientific method that would function as a* normative criterion *discriminating between science and pseudo science.*

**The hypothetico-deductive model** – The model for scientific method that is still most commonly held:

1. Gather data
2. Formulate Hypothesis
3. Test hypothesis

**Confirmation theory** – The idea is that observing an instance of a law counts as a confirmation of this theory.

1. Theory $T$: all ravens are black
2. Every time I see a raven which is black the theory gets confirmed

**Context of Discovery vs. Justification** – an important distinction

- HD model: context of justification
- Context of discovery : too complex – psychology

Of course, even in the case of justification, over simplistic

$\longrightarrow$ *To make a long story short, the logical positivist tried hard to give a clear, definitive, well-supported method for science. In trying to build perfect logical foundations for scientific theories, they uncovered fundamental problems !*

## 10.3 The problem of induction

### 10.3.1 Hume – the old problem of induction

**The problem** – Problem concerning reasoning about future expectations:

- Original formulation: Hume, *An Enquiry Concerning Human Understanding*, Section IV, Part 1
- Reformulated by Russell, *Problems in Philosophy* with a striking example:

> The man who has fed the chicken every day throughout its life at last wrings its neck instead, showing that more refined views as to the

uniformity of nature would have been useful to the chicken.(chapter "On Induction")

- The problem is thus: How do we justify inferences about the future when we only have access to patterns in present and past experience?
- Example: "The Sun will rise tomorrow"

**Why is induction not supported?** – Two option for supporting induction: either deductive or inductive reasoning

1. Can the justification be deductive? No, because:
   a. There is no deductively valid inferences from the present and past facts to future facts.
   b. There is no valid inference from a finite series of conjunction to an universal statement. Induction is thus not logically supported.
2. Can the justification be inductive? No, because the reasoning would be circular
   "the Sun will rise tomorrow" cannot be induced from "the Sun has risen everyday in the past", unless we assume that "the future will be like the past"
   An essential assumption in any inductive reasoning for future expectations is precisely that: *the future will be like the past*!
   "In the past, the future has been like the past" $\longrightarrow$ *circularity*
   You need to assume that the future will be like the past, in order to induce that the future will be like the past from the observation that the future has always been like the past, in the past !!

**What to take from Hume** – Serious on the philosophical level

The problem is serious: covers all our inferences about the future

That said, Hume's conclusion is *not* that we should not go on with making inferences about the future, just that we should be aware of the fact that they are not logically justifiable

**The pragmatic vindication of induction** – Hans Reichenbach

The idea is to "bet" on the hypothesis that the future will be like the past, in a Pascal's wager style:

- Pascal's wager: compare the costs and benefits in the hypothesis that : you believe in God and go to church or not / God exists or not – going to church seems a winer

| | God exists | God does not exist |
|---|---|---|
| Believe | Everlasting happiness | negligible |
| Disbelieve | Eternal damnation | negligible |

- In the same manner, according to Reichenbach: we have everything to gain and nothing to lose by using induction, whether or not Nature is uniform.

| | Nature is uniform | Nature is not uniform |
|---|---|---|
| Use induction | Succeeds | Fails |
| Use some other method | Succeeds or fails | fails |

### 10.3.2 Hempel's raven paradox

Hempel (1905-1997): one of the most prominent logical positivists:

**Confirmation reasoning** – the usual is:

$T$: All ravens are black

is confirmed by any instance of a raven which is black

$T$ is confirmed by evidence $E$: raven which is black

**A logical fact** – Logical equivalence between a proposition and its contraposition

$T$: All ravens are black :

$$\forall X, X = raven \longrightarrow X = black$$

$T*$: All non-black things are non-ravens (Anything which not black is not a raven)

$$\forall X, X \neq black \longrightarrow X \neq raven$$

That there is logical equivalence means that *the content two hypothesis is essentially the same.*

More Examples and some clarification:

- All pregnant women put on some weight

- Any woman who does not put on weight is not pregnant

CAREFUL: The two propositions above are *not* equivalent to:

- All women who put on weight are pregnant

SO:

$P \longrightarrow Q$ is equivalent to $notQ \longrightarrow notP$

BUT NOT equivalent to: $Q \longrightarrow P$

**Raven's paradox** –

- Compare:

$T1$: All massive bodies are governed by the universal laws of gravitation

$T1*$: any body which is not governed by the universal law of gravitation is not a massive body

- *If T1 and T1* are the same theory, then the same evidence should confirm both.* This means that any evidence $E$ which confirm T also confirms T* and vice-versa.

- Take T*: All non-black things are non-ravens (Anything which not black is not a raven)

T* is confirmed by evidence $E$: an instance of a non-black thing which is not a raven

$\longrightarrow$ SO: *an instance of a non-black thing which is not a raven also confirm T!!!* Any sight of a white shoe or a green leaf is a confirmation of the theory that all ravens are black.

**More paradoxes in the logic of confirmation** – irrelevant conjunctions and irrelevant disjunction

**Two rules of confirmation** :

1. If a piece of evidence $E$ confirms theory $T$, and if a theory $T'$ logically implies $T$, then $E$ also confirms $T'$

Example: If some evidence (measurement of the speed at which different bodies fall in the void) confirms the law of falling bodies and if the law of universal gravitation implies the law of falling bodies, then the evidence found also confirm the law of universal gravitation

2. If a piece of evidence $E$ confirms a theory $T$, then anything implied by $E$ also confirms theory $T$

Example: If some evidence (measurement of the speed at which different bodies fall in the void) confirms the law of falling bodies, and this evidence implies that the two bodies under study reach the ground at the same instant, then this new piece of evidence also confirms the law of falling bodies.

**The problems induced by these rules** :

We agree that: The anomalous perihelion of Mercury confirms the general theory of relativity

Hence:

1. the anomalous perihelion of Mercury confirms the theory including the general theory of relativity and that there is life on Mars

2. the anomalous perihelion of Mercury or that Edgar came to class today confirms the general theory of relativity

(Earman 1992)

### 10.3.3 The new riddle of induction –Goodman

Goodman (1906-1998)

**The problem** – Goodman notices that the following argument have the same logical form, or syntax:

Argument 1. All emeralds observed prior to 2010 A.D. are green. Probably, all emeralds are green.

Argument 2. All emeralds observed prior to 2010 A.D. are grue. Probably, all emeralds are grue.

**Grue:** an object is Grue if and only if it was observed prior to 2010 A.D. and green, or if it was not first observed before 2010 A.D. and is blue.

Not so weird as it seems:

- everything that has been observed green up to now is grue.

- things don't have to change color ! (easy misunderstanding)

While the first argument seems fine, the second does not. It seems that something went wrong with the reasoning. That said, the two arguments have the same logical form. So, if the logical form is all there is to the validity of an inductive argument, both arguments should be on the same foot.

**Goodman's conclusion** – Goodman's point is to show that *there is no purely formal theory of confirmation.*

Goodman seems to speak against the idea that the validity of inductive argument could only depend on syntax, their logical form.

His point is *not* to say that confirmation is impossible, or that induction is inevitably flawed.

His point is rather to say that to focus on the logical form of arguments, and forget about the meaning is not the right way to go to understand inductive reasoning. Attention must be paid to the content.

**The problem of projectible predicates** – It seems that we can "project" the predicate "green" in the future, while we cannot project the predicate "grue".

We should thus have a rule: use only projectible predicates in inductive reasonings.

But how to distinguish projectible predicate from non-projectible predicate?

**No easy answer** – We can't get away just in saying that grue is "constructed" while "green" is somewhat more natural

Consider:

**Grue:** an object is Grue if and only if it was observed prior to 2010 A.D. and green, or if it was not first observed before 2010 A.D. and is blue.

**Bleen:** an object is bleen if and only if it was observed prior to 2010 A.D. and blue, or if it was not first observed before 2010 A.D. and is green.

If Grue and Bleen are our basic predicates, then green will have a temporal component in it's definition:

**Green:** an object is green if and only if it was first observed before 2010 A.D. and is grue, or if it was not first observed before 2010 A.D. and is bleen.

**Blue:** an object is blue if and only if it was first observed before 2010 A.D. and is bleen, or it was not first observed before 2010 A.D. and is grue.

| | Observed before 2010 | Not Observed before 2010 |
|---|---|---|
| Grue | Green | Blue |
| Bleen | Blue | Green |
| Green | Grue | Bleen |
| Blue | Bleen | Grue |

If Grue and Bleen are our basic predicates, then it seems that Blue and Green are the predicates that are non-projectible!

**Possible answers and controversies** – Proposed exits:

1. Goodman: pragmatic: start with the language in use.

   Pb: the validity of inductive reasoning then depends on arbitrary aspects of our language

2. Use only predicates which pick out "natural kinds", and not predicate picking out an arbitrary collection

   Pb: the question of what a natural kind is is controversial since Plato!

**A concrete consequence of Goodman's abstract argument** – curve fitting

What is the "natural" way to fit a curve in order to make further predictions?

## 10.4 The Duhem- Quine Thesis

**Three key ideas** :

1. Holism
2. No crucial experiment
3. Underdetermination

**Holism** :

Reminder: auxiliary hypotheses are necessary for any confrontation of our theories with the phenomena: we test a *body* of hypotheses, never an isolated hypothesis.

Jigsaw puzzle, tree, or web of beliefs – system of interconnected beliefs with core and peripheral beliefs.

**Crucial Experiment** :

Back to Bacon: given two competing theories, it is possible to design an experiment for which the two theories have conflicting predictions. Ideally, sure way to choose: the experiment cannot tell us that the theory with accurate predictions is true, but would at least tell us that the theory with non accurate predictions is false.

Again, due to the necessary presence of auxiliary hypotheses, no crucial experiment is possible.

**Underdetermination** :

The experimental data cannot fully determine that a particular theory is the correct theory, and that competing theory are incorrect.

Various theories can be compatible with all the relevant data (in their domain) :

- they are *empirically equivalent*

- theories are *underdetermined* by the relevant available data

**Weak and strong versions** :

**Holism** – How much of the web is put into question when testing a theory?
Quine: In principle, all of them. That is to say, in principle, our core beliefs could the problem.
Duhem: less radical

**Crucial Experiment** – to what extent can data be accommodated?
- Weak version of the thesis – uncontroversial – most of the time, a disconfirming evidence can be accommodated in a theory
- Strong version of the thesis – controversial – any experimental data whatsoever can be accommodated within any theory

**Underdetermination** – How arbitrary is theory choice given the fact of underdetermination?
Weak version: at times, the available data do not point uniquely toward one of the competitive theories
Stronger version: scientific theories are not rationally induced from the data, but "social construct" instead

*Discussion question:* given our study of the history of the Scientific Revolution, which version do you think is right? Is the stronger version acceptable?

## 10.5 Falsifiability – Popper

**Karl Popper (1902-1994)** – immense success among scientists, heavily criticized among philosophers

Clear and simple (too simple?) ideas about science.

**Falsifiability as a demarcation criterion** :

Falsifiability is not a scientific method, but a demarcation criterion

Scientific theories take substantial and clear risks of being incorrect

The success of a theory is measured by the ability to survive repeated attempt of falisification

Dewitt: problems with disconfirmation "make it unlikely that disconfirmation – that is, falsification – can serve as the central feature of science"

Still important though

**Dewitt: Falsifiability as an attitude** :

Let see ways in which we can defend a theory:

| Theorie | Mental Hospital Theory |
|---|---|
| Thesis | All the patients in here are mentally ill. |
| Proposed Counterexample | Alan: Heres a guy in this hospital, Mike, who seems pretty healthy. He wakes up feeling all right, has an appetite for a good breakfast, spends some time reading and doing chores and talking with the other patients, has a good lunch, plays some Ms. Pac-Man in the hospitals somewhat-outdated video-game room, plays some basketball outside, has a good dinner, watches some TV, goes to bed, and sleeps soundly. |
| Answer Type A | Brianna: O.k., I see what you mean. Maybe not all the patients in here are mentally ill. Id like to do some further examination, but unless some evidence of mental illness shows up in my further examination of Mike, then Ill have to concede that not all the patients in here are mentally ill. |
| Answer Type B | Chris: Actually, Mikes behavior is perfectly consistent with the claim that all the patients in here are mentally ill. Mikes behavior exhibits what I call denial of reality. Mike is actually mentally ill, but hes trying to deny it by behaving as if hes not. I see this all the time and always chalk it up to denial of reality. |

Which type of answer makes the theory unfalsifiable?

| Theory | Cheese-centric Theory |
|---|---|
| Thesis | Everything is ultimately made of cheese. |
| Proposed Counterexample | Diane: Heres this book, Fun With Hypnosis: The Complete How-To Guide, and Ive examined it pretty closely. It has pretty thin pages, and Im pretty sure none of them is made of cheese. Ive also dissolved the covers in an acid bath in my basement, and Im pretty sure they were cheese-less, too. |
| Answer Type A | Ernie: Hmm . . . well, o.k., so maybe not everything in the world is made of cheese. Id like to get a copy of the book and examine it for myself, but you just might be onto something. This might be a thing that is not, in fact, made of cheese. |
| Answer Type B | Fiona:Well, you may have done your best to find the cheese of which the book is ultimately made, but you just didnt break the book down into its smallest parts. When certain kinds of cheese are made into paper, the presence of cheese cant be detected with the naked eye. If you dont find cheese in a physical object such as a book, thats because you havent looked hard enough, not because its not there. |

Which type of answer makes the theory unfalsifiable?

$\longrightarrow$ Whether or not one treats a theory as unfalsifiable depends on what we take to be the relevant evidence

**Discussion questions** :

1. What does count as sufficient evidence ??
2. What does count as relevant evidence ?? (empirical vs. scriptures)
3. Could not we say that science should take into account empirical evidence as relevant?